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### Individual property tax to fund public transport

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#### ABSTRACT

Efficient and reliable public transport is of prime concern to city dwellers. To function efficiently, public transport generally needs subsidies from the state or local government. Our goal was to design and develop an alternative model of property tax that would provide financing for public transport. It was hypothesised that if the market value of real estate depends on the proximity of public transport, property tax can be a reliable source of financing for public transport. Based on the hedonic pricing theory, we used multiple regression to measure the impact of public transport proximity on the value of residential property. The data on the market value of property and property tax was taken from statistical tax reporting forms of the Federal Tax Service. The data on various public transport infrastructure facilities was used from the specialized open registers. We tested our alternative model of property tax, using the case of the Ekaterinburg Metro and the Tram and Trolleybus Company, through regression analysis of 7,685 objects of residential property in the City of Ekaterinburg. It was found that the efficiency of the underground service is higher than that of the city's tram network. On the average, the proximity of underground stations increases the value of housing by over 6%. As predictive estimation of the amount of tax determined by the proximity of public transport showed, the alternative model of property tax is sufficient to cover capital expenditures of the city's public transport operators and could, therefore, contribute to further expansion and modernization of the transport network.

#### KEYWORDS

property tax model, public transport, property tax, property value, metro, tram

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### Налог на недвижимость физических лиц как источник финансирования общественного транспорта

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#### АННОТАЦИЯ

Эффективный и надежный общественный транспорт представляет первоочередной интерес в жизни городских жителей. Для эффективного функционирования общественному транспорту как правило требуются субсидии от государства или органов местного самоуправления. Намерение состояло в том, чтобы

спроектировать и разработать альтернативную модель налога на имущество, которая обеспечила бы источник финансирования для общественного транспорта. Гипотеза исследования основана на предположении, что, если рыночная стоимость недвижимости зависит от близости остановок общественного транспорта, то налог на имущество может стать надежным источником финансирования общественного транспорта. Основываясь на теории гедонистического ценообразования, мы использовали множественную регрессию для измерения влияния близости общественного транспорта на стоимость жилой недвижимости. Источником информации о рыночной стоимости имущества и налоге на имущество являлись формы статистической налоговой отчетности Федеральной налоговой службы. Для получения информации о различных объектах инфраструктуры общественного транспорта использовались открытые данные из специализированных регистров. Предложенная альтернативная модель налога на имущество была протестирована на примере Екатеринбургского метрополитена и Трамвайно-троллейбусной компании путем регрессионного анализа 7 685 объектов жилой недвижимости в городе Екатеринбурге. Сделан вывод, что эффективность метро выше, чем у городской трамвайной сети. Близость станций метро в среднем увеличивает стоимость жилья более чем на 6%. Прогнозная оценка суммы налога, зависящей от близости общественного транспорта, показала, что альтернативная модель налога на имущество достаточна для покрытия капитальных затрат операторов общественного транспорта города и, следовательно, может способствовать дальнейшему расширению и модернизации транспортной сети.

#### **КЛЮЧЕВЫЕ СЛОВА**

модель налога на недвижимость, общественный транспорт, налог на имущество, стоимость недвижимости, метрополитен, трамвай

### **1. Introduction**

An extensive, developed and easily accessible transport network is commonly seen as a major public good. Fiscal tools have traditionally been used by governments to finance public transport. The conceptual and methodological principles underpinning the application of these tools were described in numerous taxation theories.

An efficient and reliable municipal transport system stands high on the list of priorities of any city council. To handle this task, it is necessary to search for the ways of financing the transport network's operation and its expansion. Funding alternatives include, first and foremost, the fares charged for carrying passengers. In this case, the revenue comes from the direct users of the transport services. In the majority of cases, however, in addition to revenues from fares, to function efficiently, public transport also needs subsidies from the state and local government.

State subsidies to public transport are necessary if the revenue from fares does not cover the operating expenses. In this

case, a question arises as to what can be an alternative source of funds to close this gap.

Even though there is a variety of models for financing the maintenance needs of transport infrastructure as well as the construction of a new one, in Russia most of these innovative funding techniques have found no practical application so far.

The aim of this research is to propose a new model of property tax that would provide a reliable source of financing for municipal transport.

To this end, we are going to address the following objectives:

1) prove that the individual property tax can serve as a possible source of co-funding for public transport;

2) describe a mechanism for identifying the portion of the tax generated by the vicinity of a developed public transport system;

3) test the possibility of using this tax as a source of financing of operational and/or capital expenses of public transport operators.

Our hypothesis is that it is possible to build a property tax model that would se-

cure a reliable source of financing of public transport depending on the impact that the vicinity of municipal public transport has on the market value of real estate property.

## 2. Literature review

### 2.1. Taxes as a tool for estimation of the cost of public services

One of the fundamental taxation theories is the theory of exchange, which is conceptually based on the benefit principle and emphasizes the contractual nature of public services.

The exchange theory also had a major impact on the studies of public finance as well as decision-making in concerning public expenditures and revenue policies. De Viti de Marco [1], Wicksell [2], Lindahl [3], and later Mazzola [4] adopted the methodology of the marginalist theory of value to study public spending. These studies consider the state as a group of persons paying taxes in exchange for services (public goods), which the ultimate consumers can take advantage of. The approaches to taxation as payment for public services underpinning the voluntary exchange theory are widely applied in contemporary studies on various kinds of public services and goods.

Enoch et al. [5] use as a point of departure the ‘beneficiary pays’ principle, meaning that it is the beneficiary or the user of public goods who pays for them. This explains the practice of using taxes and charges for public transport financing, e.g. the imposition of local charges on the inhabitants of specific areas and other taxpayer groups (e.g. employers) that would benefit from the access to public transport.

Keid [6] demonstrates that the cost-effectiveness of public transport as a public good, which can be replaced by commercial alternatives, can be measured through the quality to cost ratio, the latter taking the form of taxes spent on financing these goods. The assessment of cost-effectiveness normally encompasses the tax burden levels borne by groups of households depending on their income.

In practice, the principle ‘beneficiary pays’ may be difficult to realize since this

approach is based on the estimation of the fairness and efficiency of the calculations of the tax-burden-to-income ratio, which makes it hard to compare the actual taxes paid with the value of the public goods one can benefit from [7].

Governments tax citizens not only to produce pure public goods but also to produce and distribute specific commodities. Aaron & McGuire [8] argue that it is difficult to break down the tax revenue from each household into distinct components, one of which is spent on public goods and the rest go to other purposes.

Access to certain types of public goods (including transport services) directly depends on the location of the taxpayer’s household. This allows us to consider specific taxes as a fair price for the access to such public good (see Van den Branden et al. [9], Ubbels [10]).

The amount of public goods and sources of their financing are discussed at length in the works of Anthony B. Atkinson, who proposed a formula of the optimal balance of public production [11].

Atkinson also compares the optimal level of public goods provision in relation to distorting and non-distorting taxation. He demonstrates the possibility of achieving a higher level of public goods provision while using lump-sum (non-distorting) taxation [11].

Thus, there is considerable research evidence that financing of public goods involving the use of the least distorting taxes is an effective instrument for maintaining the optimal level of public goods provision.

### 2.2. Taxpayer funds as a source of public transport financing

Private vehicles are among the major causes of traffic congestion and air pollution in cities. The main theoretical premise behind transport taxation is the need to reduce private car usage and to curb its negative effects [12; 13]. Such regulations may rely on fiscal tools of different kinds. Some countries use toll charges to regulate the traffic on central streets with public transport being exempt from tolls.

Farrell [14] investigated the system of taxes and charges in Scandinavian countries for financing the development of the road network and municipal transport. She also mentions the Golden Gate Bridge toll in San Francisco (USA), which also has a targeted character and is spent on the Bridge's maintenance and related public transit services [14]. These funds are then used to finance bus lines and ferry services.

Another variation of the 'polluter pays' principle is the model where a funding source for public transport is provided by consumption taxes. Taxes embedded in the price of commodities polluting the environment help regulate their consumption and engender extra revenue. Buehler & Pucher [15] analyzed and proved the efficiency of this approach in various countries.

In this case what matters is not only the direct financing for public transport from tax revenues but also an increase in ridership and in ticket sales. Austin & Dinan [16] associate this effect with the changes in consumer preferences found in completely different city types. Tanishita et al. [17] point to the much higher level of efficiency in this type of taxation in comparison with the taxation of private vehicle owners.

Tax revenues from polluters may be raised not only through fuel taxes but also through taxes on car ownership [18]. In this case, there may be two possible influences on public transport: greater reliance on more environmentally friendly collective means of transportation and generation of extra funds for the development of the public transport and road network. Sandmo [18] described the conceptual framework for a large number of models focused on the replacement of private vehicles by public transport.

A fundamentally different approach to public transport financing is by taxing beneficiaries. White's [19] concept is a form of 'collective purchase' of services followed by benefiting from them. There are two distinct types of beneficiaries: employers and property owners. An example of such taxes raised on employers for transport purposes is the French *versement* tax levied on the total gross salaries. Ub-

bels & Nijkamp [20] in their study of taxation on property owners highlighted that such taxes may include an addition to the tax base generated through the adjacency to public transport.

Thus, the models of taxation of public transport users can be divided into three groups:

1. Financing public transport from the common funding 'pot' (the so-called 'all-in-one-pot' principle), replenished from tax receipts. This form of financing is the most common. It is based on the following conventional mechanism: money is allocated from the budget formed through 'general' taxation. In this model, the government raises revenue from different taxable sources and public transport has to compete for funds with other public services such as health care and education. Transport is often not among the top priorities of public spending. Moreover, the amount of tax in this case is unrelated to the taxpayer's use of this service.

2. The 'polluter pays' principle means that the revenues from taxes on private vehicle use and ownership are earmarked to specific spending purposes. These funds may be spent not only on pollution prevention and control but also on the development of public transport, which has a lower environmental impact.

3. The 'beneficiary pays' principle means that public transport is financed by taxing direct beneficiaries, that is, those enjoying direct or hidden benefits from the use of public transport.

Our literature review has shown that in global practices of public transport financing, these instruments may be employed differently and are based on different mechanisms of co-funding.

### 2.3. Modern approaches to financing public transit

In some cases public transport is financed from the special fund replenished through special taxes and charges earmarked for this purpose. Vigrass & Smith [21] described this model by using the case of the *versement* transport tax (VT) in France, which is a tax levied on the total

gross salaries of all employees of companies of more than 11 employees. It is a local tax earmarked specifically for financing transit. The general VT rate is 11.5%. The VT is a powerful tool that covers about 39% of the costs of public transport in France [21]. The amount of this tax does not depend on the consumption of transport services but is a payment for the possibility to use the transport network.

Owen et al. [22] discuss this approach by looking at the case of the transport program in Los Angeles (USA), which was funded through a half-cent (0.5%) sales tax. What is interesting about this program, which includes plans for development of bus routes and rail transport, is that the funds are raised through indirect taxation.

Pucher [23] argues that another viable approach is to tax car owners since private vehicles have a much greater negative impact on the environment. Such approach can be illustrated, for example, by the gas tax in the Provinces of Quebec and Ontario, a portion of which is transferred to finance public transit. This portion is expressed in kind and is added to the cost of every litre of gasoline. Apart from the apparent simplicity of this approach, it also discourages environmental pollution.

Jalon et al. [24], however, point out that the main drawback of this kind of financing resides in the lack of clear connection between the expenditures of public transport companies and the effects resulting from their operation.

Dye & Merriman [25] reveal the potential of the mechanism called Tax Increment Financing (TIF). TIF is a model of financing infrastructure development projects based on the expectation of the tax revenue growth resulting from the improvements of the area in question. An infrastructural project is expected to increase the cost of the property and/or land of the neighbouring areas and also increase the tax revenue, thus allowing the authorities to avoid raising the tax rate. All such tax increments or only their part, including the revenue from the infrastructural project itself, are redistributed in favour of the TIF-project's operator

until the end of the project and are used to cover the initial investment into the project.

Man & Rosentraub [26] studied the outcomes of a TIF program and found that there was an increase in the revenue from the sales tax and an increase in the number of jobs. The conclusion they make is that the TIF program had a positive effect on urban economy.

Some authors are less appreciative of the benefits of this tool. According to Clark & O'Connor [27], TIF is based on the investment that implies an increase in the value of property, which in the conditions of an 'opaque' financial market can lead to dubious consequences. Housing bubbles can result in a collapse in property prices, which, in its turn, will make the developer's unable to return the investment.

Weber [28], on the contrary, shows that the application of the TIF tools during the real estate bubble crisis in the US allowed some of the municipalities that implemented infrastructural projects to avoid the harmful effects of the crisis. For instance, the crisis in 2007 had no effect on such projects in Chicago and other American cities.

Smolka & Furtado [29] demonstrated that large public transport stations provide ample opportunities for the development of commerce and commercial property. Such projects in Brazil, namely in Porto Alegre and Belo Horizonte, were quite successful primarily thanks to the modernization and clustering of residential property areas along the lines of public transport. In Curitiba, however, a similar project was not successful due to land speculation and the displacement of the poor to the suburbs.

Cocconcelli & Medda [30] showed that in order to prevent the appearance of speculative bubbles in the real estate market, it is necessary to conduct property value assessment in due time and regulate the property tax rate in case of sharp fluctuations of the tax base.

Bourassa [31] uses the case of Pittsburgh to illustrate that an increase in the rates of land value taxes can cause significant resentment on the part of the tax-

payers and that the failure to generate good PR of an infrastructural project may also lead to the project's closure.

Our literature review has shown that the most widely spread approaches are those based on state financing of public transport. The TIF model appears to be practically applicable since it is based on a rather simple calculation mechanism and establishes the connection between the efficiency of public transport and its financing.

### 3. Methodology

Table 1 shows the key stages in our research and the corresponding methods.

Table 1

| Key stages of the methodology |   |   |
|-------------------------------|---|---|
| No                            | Stage   | Description   |
| 1.                            | Identification of the beneficiaries   | By applying the hedonic pricing model we determined the impact of public transport on the cost of property              |
| 2.                            | Identification of the property tax base generated by public transport       | Calculation of the share of the tax base generated by public transport  |
| 3.                            | Analysis of the general property tax base                                   | Identification of the property tax base generated by residential property alone   |
| 4.                            | Calculation of the amount of the property tax generated by public transport | Calculation of the portion of the property tax generated by the vicinity of a developed public transport infrastructure |
| 5.                            | Projected estimates of the bonus payment to the public transport operator   | Estimation of the operator's actual expenditures and the comparison of this figure with the amount of the bonus payment |

The most widely used methodology for measuring the impact of a certain attribute on the general cost of a property is based on the hedonic theory. The hedonic pricing model is a standard econometric instrument for evaluation of determinant attributes of various goods, in particular residential property [32]. The hedonic model for calculating the value of property [33]

determined by the proximity of transport infrastructure confirms the supposition that there is indeed a dependency between the value of property and public transport accessibility [34]. This model can also be used to estimate this dependency for taxation purposes [35].

The elements of our model for calculating the amount of the tax to be transferred to public transport operators as an efficiency bonus are as follows:

1. Sources of all the necessary data;
2. Methodology for data processing;
3. The frequency of iterations for calculating the base cost of a square metre and the coefficient of transport accessibility;
4. Methodology of calculating the share of the property tax to be transferred to a public transport operator;
5. Government agency responsible for the implementation of this mechanism

In our choice of data sources we followed the principle of transparency, which is the key principle used for mass appraisal of real property for taxation purposes. To estimate the impact of public transport on the value of property, we chose open sources of data over specialized registers with restricted access. Thus, we were able to justify the need to transfer tax receipts to public transport operators.

In our calculations of the model, we relied on the following data types:

- Information about the market value of property;
- Information about the amount of property tax accrued;
- Information about different objects of the public transport infrastructure

All of the above-mentioned types of data are publicly available. The Federal Tax Service publishes the accrued property tax data on their official web-site on an annual basis.

Objects of the public transport infrastructure are used in the model in the form of data on geographic coordinates of transport stops. Such coordinates were obtained from online map services, including free ones.

The information about the market value of property as well as the characteristics of these objects can also be ob-

tained from various sources such as the publicly available online information about the cost of property for sale and specialized property registers. The latter include the information about purchase and sale property transactions registered in the Federal Service for State Registration, Cadastre and Cartography (Rosreestr). Rosreestr provides more accurate data since they take into account all the discounts made by sellers and included in the original cost of the property as shown in real estate ads. Eventually we chose publicly available information sources to increase the transparency of our analysis.

To measure the impact of transport infrastructure proximity on the cost of a residential property, it is better to use multiple regression, which is the most widely used method for measuring the impact of a certain attribute on the object's total cost based on the hedonic pricing theory. According to this theory, the property can be considered as a commodity whose price depends on the group of cumulative characteristics. These include not only inherent qualities of the property but also the overall ambience of the location and accessibility of certain infrastructure objects.

The next question to be considered is the choice of a model calculation method for the whole individual property tax base. The most suitable method, in our view, is to calculate the share for each individual property and then extrapolate the results of the model proportionally to the whole tax base.

The tax base for the individual property tax comprises not only the value of residential but also non-residential property such as garages, parking space, etc. We can calculate the share of the tax revenue to be transferred to a public transport operator as an efficiency bonus in a computational model (using the real estate data) and the adjustment coefficient will be applied to calculate the share of the tax base corresponding to residential property. The information on the distribution of the tax base by property type can be obtained from statistical tax reporting forms

5-MN published on the official website of the Federal Tax Service.

In our study, we are going to rely on the aggregate statistical data from open official sources. The resulting model was estimated by using individual property tax revenue in Ekaterinburg.

## 4. Results

### 4.1. Analysis of public transportation funding models

There are three general models of public transport financing:

1. Reimbursement of the public transport operator's actual expenditures. In this scheme, the operator's expenditures are covered from the public budget formed through general taxation revenues. The amount of transfers to the operator depends on the operator's general operational expenses. Since the amount of the necessary funds will vary in different years and due to the lack of the tax base that could be assigned to the sum of the operator's expenses, the most widely used approach is the so-called 'all in one pot' method. Since in this model all sources of tax revenue are used, we can conclude that the costs of public transport are covered by all the taxpayers, regardless of whether they actually benefit from these services or not.

2. Reimbursement of the public transport operator's expenditures through the costs paid by owners or users of private vehicles since cars are the biggest contributors to air pollution in urban areas and other issues such as congestions, road accidents, etc. This principle is underpinned by the idea that public transport provides a 'healthier' alternative to private vehicles. Collective use of public transport reduces these negative effects and is, therefore, seen as a more sustainable and preferable alternative. In this model, transport taxes and fuel levies play a crucial role: the revenue coming from these sources is directed to fund the public transport network.

3. The bonus payment to the developer building a certain object of transport infrastructure comes from the tax revenue generated through the positive externali-

ties from this developer’s work. What distinguishes this model is that the amount of financing depends on the positive effect of the operator’s activities rather than on the operator’s expenditures. This model may rely on general tax revenue as well as on specific taxes or on beneficiaries (Table 2).

All of the above-described models are by no means the optimal solution to this problem. What they have in common is that they all deal with the ways of reimbursing the expenses of public transport operators or developers engaged in construction of transport infrastructure. It should also be noted that these models do not take into account the efficiency of public transport operations and its utility for individual taxpayers.

In our view, the optimal model would be to use a part of the individual property tax for this purpose. The tax base for this tax is the value of property, which, in its turn, is partially affected by the accessibility and efficiency of the public transport network. It is this increase in the tax revenue that could serve as a source of financing for municipal transport and its modernization.

The main idea behind the proposed model is to estimate the possibility of identifying the amount of the property tax revenue generated through the development of the transport network in a given area and to test the sufficiency of this sum for financing transport operation and modernization depending on the efficiency of the operators.

**4.2. Financing of public goods through distorting and non-distorting taxes**

To demonstrate the role that taxation plays in public transport financing, we intend to use the formula reflecting the consumption of goods by the whole community. This formula was derived from Atkinson’s equation [11]:

$$pHX + (p_g G_{loc} + p_g G_{gov}) = HL, \quad (1)$$

where  $HL$  is the consumption of goods in the community ( $L$  is the individual level of consumption);  $p$  is the cost of a private good;  $HX$  is the consumption of a private good by the community ( $X$  is the individual level of consumption of a private good);  $G_{loc}$  and  $G_{gov}$  are the possibilities of production of public goods by local authorities and the national government respectively;  $p_g$  is the cost of production of public goods by local authorities and the national government.

Since public transport is one of the local public goods, it would make sense to present the production of public goods as a sum of production of different goods that qualify as local. To analyze ways of transport financing, we are going to consider the production of local public goods as a sum of public transportation services (denoted as  $p_g G_{tran}$ ) and other local public goods (denoted as  $p_g G_{loc.other}$ ):

$$pHX + (p_g G_{gov} + (p_g G_{loc.other} + p_g G_{tran})) = HL. \quad (2)$$

This formula can be used to compare the results of financing of public goods production in different models.

Table 2

**Relationship between the sources of public funding and mechanism of reimbursement for municipal transport operators**

|   | Reimbursement of the operator’s actual expenditures | Reimbursement of the operator’s expenditures is provided from the funds collected from the owners of private vehicles, which have a negative environmental impact | Bonus payment to the developer building a certain object of transport infrastructure comes from the tax revenue generated through positive externalities from this developer’s work |
|---|---|---|---|
| Reimbursement from general tax revenue ('all-in-one-pot') | +   |   | +   |
| 'Polluter pays' reimbursement                             |   | +   |   |
| 'Beneficiary pays' reimbursement                          | +   |   | +   |



Let us now consider the alternative way of financing through the distorting tax charged on the consumption of private goods. To this end, we will present  $p$  as a sum  $(p + t)$ , where  $t$  is the tax rate:

$$(p + t)HX + (p_g G_{gov} + (p_g G_{loc.other} + p_g G_{tran})) = HL. \quad (3)$$

In the situation where all the taxes raised are spent to produce public goods, the sum of the tax (denoted as  $T$ ) will be equal to the sum of all the public goods. The formula will look the following way:

$$(p + t)X + T = L. \quad (4)$$

To achieve the optimal public welfare, it is necessary to maximize individual utility ( $U_x$ ):

$$U_x = a(p + t), \quad (5)$$

where  $a$  is the marginal individual utility equal to  $U_t$ .

An increase in public utility is achieved through maximization of the sum of individual utilities ( $HU$ ) and can be expressed through the Lagrangian in the following way:

$$\mathcal{L} = HU(X, L, G) - \lambda(pH + p_g G - HL). \quad (6)$$

Extrema of this expression are equal to zero of the derivative function shown above.

$$\frac{\partial \mathcal{L}}{\partial G} = HU_G - \lambda \left( p_H \frac{\partial X}{\partial G} + p_G - H \frac{\partial L}{\partial G} \right) = 0. \quad (7)$$

After transforming the resulting equation, we obtain the following:

$$\frac{HU_G}{a} = \frac{\lambda}{a} \left( p_G - tH \frac{\partial X}{\partial G} \right). \quad (8)$$

The main conclusion that can be made by looking at the right side of the given equation is that an increase in the level of public goods significantly limits the possibility of increasing the revenues from distorting taxes used to finance such goods.

Returning to formula (3), let us consider the impact of a non-distorting tax on the balance of the public goods production. In this case, the tax will be in the right-hand side of the equation, which will look the following way:

$$pHX + (p_g G_{gov} + (p_g G_{loc.other} + p_g G_{tran})) = HL + T. \quad (9)$$

The above formula illustrates the neutrality of non-distorting taxation in relation to private goods consumption.

A significant characteristic of local public goods is that the range of potential users is spatially limited. Therefore, a community (a city district or a city) can be considered as a single location with a more or less homogeneous public transport infrastructure. The access to public transport is thus enjoyed primarily by those who inhabit this territory (e.g. own a property located in this area). Although formally public transport can be used by non-locals, members of other communities, in practice this does not happen very often due to the distance factor.

Thus, we believe that, making a certain assumption, property taxes are the taxes with the minimal level of distortion in what regards public transport. Therefore, property taxes hold much promise for financing public transport.

This way of financing, however, does not exclude other mechanisms of funding local public goods such as transport.

### 4.3. The model was tested by using the case of Ekaterinburg (Russia)

To provide financing for urban transport operators through the mechanism described above, we need to calculate the share of the tax corresponding to the impact of the transport infrastructure on the value of residential property.

Since the fiscal period of the property tax is 1 year, it would be reasonable to estimate the impact of public transport on the value of residential property no more frequently than once a year.

Municipal public transport is controlled by local authorities, which is why it would make sense that local authorities should be made responsible for calculating the amount of bonus payments to the public transport operators.

For our study we chose two operators of public transport in Ekaterinburg: Ekaterinburg Metro (*Ekaterinburgskiy metropoliten*) and the tram and trolley-bus company (*Tramvayno-trolleybusnoye upravlenie*). Ekaterinburg is a large Russian city with a developed public transport network com-

prising almost all modes of public transport. The city’s population size is about 1.5 million and the city ranks high in Russia in terms of the number of private vehicles. The volume of passenger traffic of the city’s public transport is over 400 million people a year. Lately, however, the passenger flow has been steadily decreasing, which can be explained by the low quality of transport services and the insufficient efficiency of public transport operations. The shrinking passenger flow creates a scarcity of funds of the public transport company for further development of the network.

The above-described mechanism for calculating bonus payments is shown in Figure 1.

This mechanism is based on estimating the impact of the proximity of the public transport infrastructure on the market value of residential property and it requires no complex calculations or computational tools, which is why no extra jobs or new software will be necessary for its implementation.

In our previous studies [36], we calculated the median values of the impact that the transport infrastructure proximity has on the cost of real estate property in Ekaterinburg. The closer is the property to the transportation network, the more benefits are enjoyed by the owner of this property. Moreover, the more efficient is the public transport, the more significant is the influ-

ence of its proximity on the value of the property. In our view, the latter may serve as an indirect indicator of the public transport operator’s efficiency or inefficiency. The calculated values of the impact of public transport proximity on the cost of property are shown in Table 3.

Table 3

**Impact of public transport stops proximity on property prices in Ekaterinburg, %**

|                | Minimum value | Maximum value | Median value |
|----------------|---------------|---------------|--------------|
| Metro stations | 3.00          | 12.00         | 6.09         |
| Tram stops     | 3.20          | 8.80          | 5.47         |

These figures were obtained through regression analysis of 7,685 objects of residential property in Ekaterinburg. It can be concluded that the efficiency of the underground service is higher than that of the city’s tram network. The proximity of underground stations on average increases the cost of housing by more than 6%.

We used the data gathered through our previous research to determine the projected values of transfers to the tram and trolley-bus company and Metro. To take into account the fact that the individual property tax is imposed not only on residential but also on non-residential properties, we introduced an adjustment

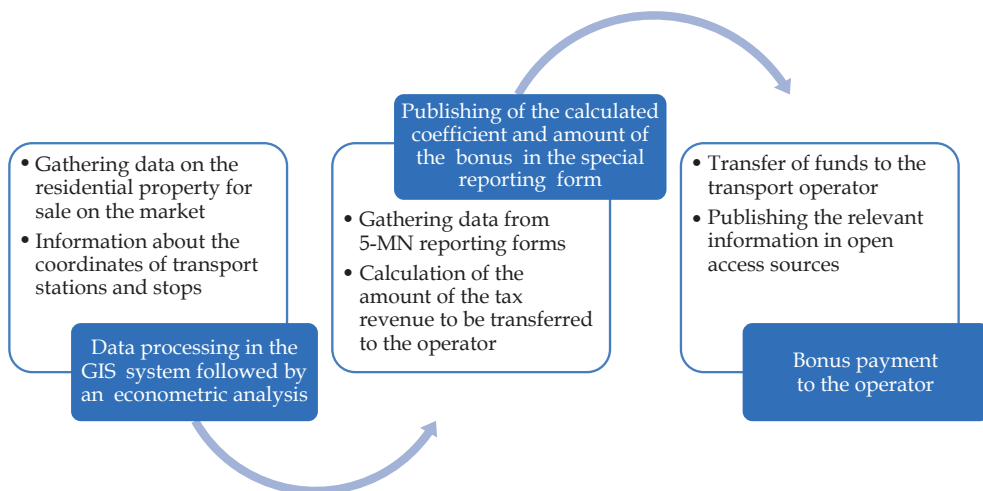


Fig. 1. Mechanism for calculating bonus payments to public transport operators

coefficient, which corresponds to the share of the tax base on residential property of the general property tax base. For Ekaterinburg, this coefficient is 0.76696.

According to the 2019 budget report, the total amount of the tax revenue was 1,337,546 thousand roubles. The sum resulting from the adjustment for the coefficient was 1,025,844 thousand roubles. We used the median values of the impact that the proximity of transport had on housing prices to calculate the tax revenue to be received by the operators (see Table 4).

Table 4

**Projected amount of funding transfers to the public transport operator**

| Public transport operator    | Projected funding in 2019, ths rbs |
|------------------------------|------------------------------------|
| Tram and trolley-bus company | 56,113                             |
| Metro                        | 62,473                             |
| <b>TOTAL</b>                 | <b>118,586</b>                     |

We will use the estimated value of the bonus to a public transport operator to find whether these funds will be sufficient to modernize the transport infrastructure or not. At the beginning of 2019, Ekaterinburg Metro had to borrow funds on loan – 486 million roubles for 8 years – to buy new carriages. The costs of servicing the credit line are 208.2 million roubles. At the same time, Ekaterinburg Metro raised their fares by 14.2% or 4 roubles in order to finance the investment program to modernize the underground fleet.

Thus, the Metro's capital costs were covered from the fares paid by the passengers. It should be noted that the 'beneficiary pays' funding was not used. The performance bonus paid to the Metro's operator would help either to reduce the interest paid on borrowed funds or to attract outside investment through the TIF mechanism with reduced rates due to the guaranteed receipt of funds in the form of bonus.

Our estimation of the amount of the bonus payment to operators of the tram and trolley-bus services and of the underground in Ekaterinburg has shown the feasibility of this mechanism. We have also illustrated the possible effect from such bonus payments for cutting the transport operating costs.

## 5. Conclusion

Efficient operation of public transport is impossible without state co-funding. In this case, the operating and investment costs of public transport are covered by the revenues gained from some taxes or charges. Despite the distorting influence of taxes, the most suitable tax is the individual property tax.

We conducted predictive estimation of the amount of tax determined by the accessibility of public transport. Our calculations took into account the proximity of transport on the value of property (the tax base for the individual property tax). Following the existing theoretical and empirical literature, we developed our own model of the individual property tax, capable of generating sufficient funding for public transport as a part of the revenue is earmarked specifically for this purpose.

This model was tested by using the case of Ekaterinburg. It was demonstrated that the amount of financial resources that could be generated through this source is sufficient to cover the capital expenditures of the city's public transport operators and could, therefore, contribute to further expansion and modernization of the transport network.

We have also confirmed our hypothesis that it is possible to build a property tax model that would provide a reliable source of financing for public transport depending on the impact of the transport infrastructure's proximity on the market value of property.

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